A BALLOON-BORNE MARS ANALOG PLATFORM FOR 'FIELD' TESTS OF IN SITU INSTRUMENTS.

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Introduction: The technology Readiness Level (TRL) metric indicates flight-worthiness. TRL 4 requires successful demonstration in a laboratory setting in 'breadboard' form. Advancement requires a more integrated instrument package ('brassboard') and operation in a 'relevant environment'.

In September 2011 JPL will launch the Analog Site Testbed for Readiness Advancement (ASTRA) – a stratospheric balloon carrying three TRL 4 instruments designed to perform in situ investigations on Mars' surface. The instruments (described below) are a mass spectrometer (RAMS), and two anemometers (SASA and HWA). A successful flight will demonstrate the instruments' capabilities and autonomy, advancing their TRL to 5 and taking significant steps toward TRL 6. It will also support reuse of the balloon platform for advancement of other instruments.

A Remote "Field" Site: Field testing of instruments in Mars analogs such as deserts and the Antarctic dry valleys can demonstrate their robustness and autonomy. These sites may approximate temperature and humidity conditions, but are wetter, warmer and (always) at higher pressure than Mars' surface. The terrestrial stratosphere possesses several superior Mars analog characteristics: 6 mbar total pressure, temperatures down to -70°C or below, a radiation-dominated thermal environment, oxidizing species (e.g., ozone), and wind.

Fig. 1 shows the ASTRA flight profile. The Columbia Scientific Balloon Facility will launch ASTRA from Ft. Sumner, NM.

Rapid Acquisition Mass Spectrometer (RAMS): Atmospheric composition constrains the state and evolution of volatile materials on terrestrial planets and moons [1]. Isotopologues of H_2O, CO_2, N_2, and noble gas ratios reveal daily and seasonal exchanges between existing reservoirs [2,3] and are keys to historic at-

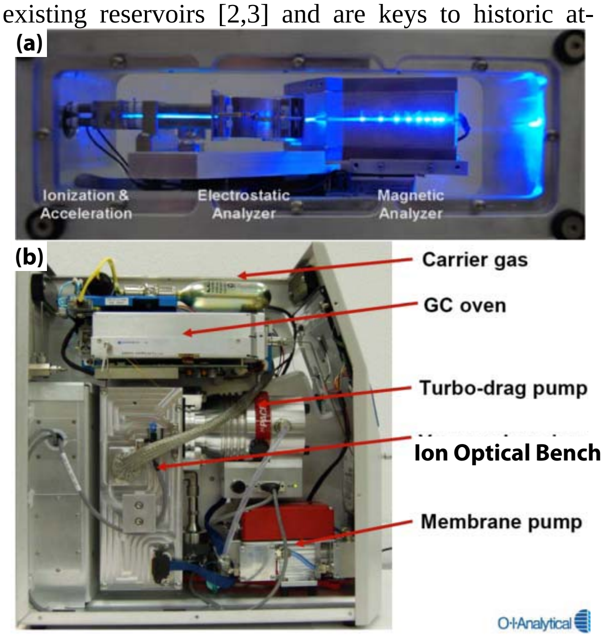

Fig. 2: (a) RAMS Ion-Optical bench with Ion-Cam CCD detector on right. (b) Unmodified commercial unit from OI Analytical. The ASTRA flight unit uses a ion pump and eliminates the GC oven, allowing rapid sampling, but the Ion Optical Bench is identical.

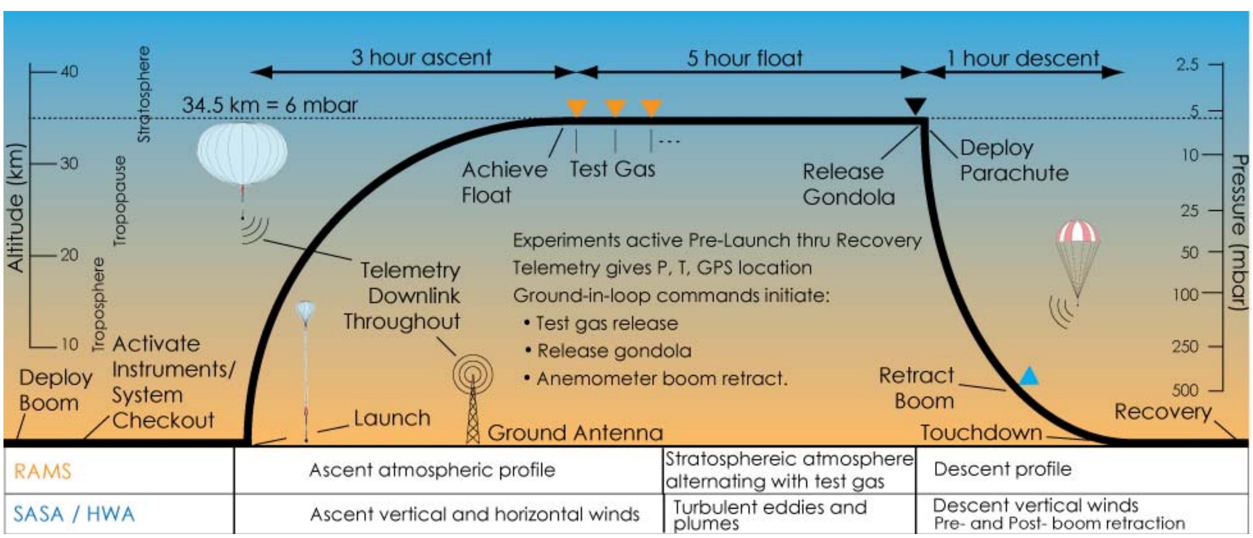

Fig. 1: ASTRA launches with all instruments activated, recording ascent and descent profiles as well as the at-float environment. All data is recorded to on-board solid-state memory, with data snapshots transmitted to the ground station in real-time. All instruments are shut down following boom retraction but before touchdown.

mospheric states [4]. Trace species (e.g., CH_4) may indicate biological activity or geological processes.

The focal-plane RAMS, developed at JPL [5,6], combines the advantages of high sensitivity (down to 1 ppm), and a large linear dynamic range (>10^3), with extremely rapid (<100 ms) acquisition of the entire mass spectrum from 7–150 amu with isotopic (0.25 amu) resolution. OI Analytical for terrestrial applications. On ASTRA, RAMS measures abundances of neutral atmospheric gases and demonstrates rapid spectra acquisition. In-flight measurement of a calibrated test gas will validate the RAMS's capabilities. A fully matured RAMS system will be capable of capturing transient events, such as laser ablation of volatiles, which require rapid, high-resolution mass spectra acquisition.

Single-Axis Sonic Anemometer (SASA): Sonic anemometers, the preferred technique for high-precision terrestrial wind measurements [7], are robust to ambient pressure or temperature variations. But standard transducers do not perform well at low pressure. ASTRA operates a pair of new capacitive sonic transducers [8], possessing acoustic impedances appropriate for coupling to the thin Mars atmosphere [9]. Acoustic pulse time-of-flight indicates the wind velocity component along the transducer axis. SASA, developed at Cornell University [10], advances martian anemometry via superior measurement frequency and resolution, simplicity of data reduction, and signal-to-noise ratio. This advance is clear when one compares the capabilities of a full 3-axis sonic anemometer (3-D, 100 Hz, 0 – 50 ± 0.001 m/s) to the Phoenix Telltale (2-D, 0.02 Hz, 1 – 17 ± 0.2–0.4 m/s), and Mars Pathfinder HWA (2-D, 1Hz, 0 – 80 ± > 0.1 m/s).

Hot-Wire Anemometer (HWA): The ASTRA HWA is the latest generation of an instrument that first flew on Mars Pathfinder. Though the relationships between wind speed, heater power, solar heating, and parasitic cooling make data interpretation challenging, the compact size and proven capability of HWAs make them viable instruments for martian anemometry. Modifications to electronics and thermal wire designs were made for the canceled Netlander mission [11]. These include a hybrid multiplexer (MUX) and sensor head isothermal block (ITB), reducing cabling mass and improving thermocouple signal.

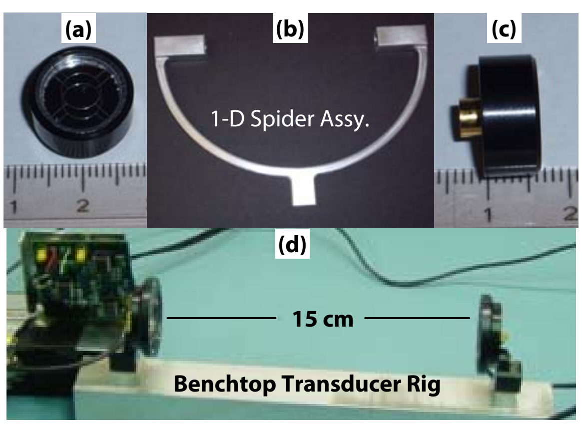

Fig. 3: (a, c) SASA ultrasonic transducers have good acoustic impedance match to the martian atmosphere. (b) The aluminum spider assembly has low thermal expansion, maintaining a constant distance between transducers during operations. (d) SASA has been tested in STP and static vacuum chamber conditions.

HWA and SASA are oriented for vertical sensitivity to observe winds experienced during ASTRA ascent and descent. At float, turbulence or eddies may be observed. Adjacent mounting on a retractable boom and GPS timestamped data permit comparison of the HWA and SASA data. The data are also validated by comparing measured wind velocities to GPS-derived vertical velocities during the initial descent.

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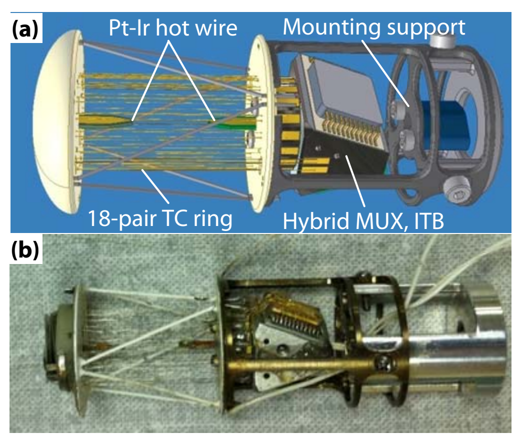

Fig. 4: (a) HWA schematic showing strut assembly with 18 thermocouple pairs in a ring (yellow) for wind-direction determination, Pt-Ir hot wire (center of TC ring) for wind-speed, the hybrid MUX and isothermal block, and mounting support. (b) completed engineering model. The HWA is 3.5 inches long.